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SEG

Special Report

Geophysical Activity in 1985

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Special Report
Geophysical Activity in 1985

SEG

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Report of the SEG Geophysical Activity Committee. Members of the Committee are Gerald E. Montgomery, Chairman, Data Analyst Russell J. Senti, and Lionel Cane, Charles E. Curtis, Kevin L. Debasitis, John Doherty, Harry R. Espey, Lin Evans, Ronald R. Hartman, Richard Hopkins, Fritz P. Kronberger, Robert C. Lucas, James Side, Mike Spradley, Frank Stirling, Paul L. Stoffa, Tommy A. Tillery, A. H. (Tony) Watts, and M. D. (Don) Watts.

Introduction

This report presents statistical data on worldwide geophysical activity in 1985. These data were gathered from survey questionnaires that were mailed to 439 oil companies, contractors, government agencies, and institutions throughout the free world. We have attempted to gather data from all users of geophysical techniques in the areas of petroleum, mining, geothermal and groundwater exploration, and from those who employ geophysical methods in engineering, environmental, oceanography, and research. Two hundred and fourteen (214) questionnaires were returned with data for this report. This compares to 218 returns for the 1984 report.

Detailed information was gathered on airborne, drill hole, land, marine, and transition zone geophysical surveys. Statistics were compiled on miles of coverage, number of stations, drill hole footage, time spent in crew-months or man-months, and acquisition costs. Data not supplied on the questionnaires by the respondents were estimated on the basis of massive statistical averaging for the area and techniques reported. This process is necessary to avoid distortion of individual statistical items.

This report, when compared to past annual reports, provides a basis for detecting and analyzing trends in technological developments and exploratory trends in geographical areas. Changes in these trends reflect the influence of factors, such as an oversupply of a particular natural resource, technological advances, and changes in economic conditions, governmental regulations, and exploration philosophy. Cost figures are also sensitive to many factors, such as operational environment, length and nature of the survey, type of instrumentation, etc. Unit costs reported by universities are substantially lower than those reported by industry due to the use of student labor and donated equipment. These costs, however, must be averaged with industry costs to accommodate the format of the report. Therefore, when examining unit cost figures, one must be cognizant of the broad spectrum of activity embraced by individual categories.

All comparisons to 1984 data in this report refer to the revised report published in February 1986 and to the accompanying Errata published in May 1986.

In response to monitoring new technological advances, the annual questionnaire forms mailed this year (and last year) contained revisions to include geophysical methods not reported separately in other years. The new methods itemized for reporting are vertical seismic profiles (VSP) and 3-D seismic surveys. Activity information was also requested on surveys performed in transition zones, the areas between normal marine and land surveys. Additional survey objectives included on this year's form were environmental and petroleum development. Reported data on these methods and objectives are included in the tables for the first time in this 1985 report.

Table 1. Total worldwide expenditures in US$ (thousands) by survey type and objective.

	Petroleum[1]									
Type	Exploration	Development	Minerals	Environmental	Engineering	Geothermal	Groundwater	Oceanography	Research	Total
Land	1,707,378	28,386	11,088	3,529	1,318	1,271	1,424		7,924	1,762,336
Transition zone	48,241	1,818			16			44	243	50,362
Marine	1,052,032	84,208	1,940		5,034			7,237	15,945	1,166,396
Airborne	28,649		9,151	10				1,942	2,898	42,649
Drill hole	3,136	1,508	201	52	506		252		171	5,827
Total	2,839,436	115,920	22,380	3,591	6,873	1,271	1,676	9,223	27,200	3,027,570

[1]Includes processing and interpretation costs for land, marine, and transition zone. See text for details.

Note: All tables in this report where figures are expressed in thousands of dollars have been rounded off as individual items; but the computer keeps track of all the truncated numbers and then the sums of the individual items are rounded off. As a result of this procedure, the rounded individual items may not add up precisely to the rounded sums.

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1985 Highlights

Worldwide expenditures on geophysical exploration in 1985 were down 12.9 percent from 1984 (see Table 1). This reduction reflects the decrease in total petroleum expenditures which were down 12.8 percent and consist of 97.6 percent of the total expenditures on geophysical exploration. Mining, engineering, and geothermal showed decreases of 49, 58, and 20 percent, respectively. Expenditures on both groundwater and research doubled over 1984 and oceanography increased by 5 percent. The added category of environmental accounted for only .1 percent of the total. There was a decrease of 13 percent in expenditures for land, transition zone, and marine petroleum exploration and development in 1985 compared to 1984. There was also a decrease in land minerals, but an increase in marine mineral exploration. Use of geophysics for petroleum development in 1985 consisted of 1.6 percent of total petroleum expenditures for land activity, 3.6 percent for transition zone activity, and 7.2 percent for marine activity. Total transition zone expenditures were 1.7 percent of all geophysical exploration dollars spent in 1985 worldwide.

Distribution of expenditures by geographic area and survey objectives is shown in Table 2. Forty-four percent of all expenditures for geophysical work was spent in the United States, compared to over 50 percent in 1984. The following areas showed a decrease in total geophysical expenditures: United States (−25%), Far East (−23%), Australia/New Zealand (−20%), Africa (−19%), and Europe (−6%). The following areas showed an increase: South America (+35%), Canada (+22%), Middle East (+22%), and Mexico (+19%).

The costs of processing and interpretation are included in Figures 1 and 2 and the petroleum columns of Tables 1 and 2. All other tables show acquisition costs only. Average costs of processing and interpretation were obtained from various processing contractors and oil companies to arrive at a figure of U.S.$565.00 per line-mile for both the Western and Eastern Hemispheres. This is a decrease of 20 percent from the processing and interpretation cost figures used in 1984.

Petroleum exploration

Over 98 percent of all geophysical dollars were spent on petroleum exploration and development (U.S.$2.9 billion) in 1985. Expenditures for petroleum exploration and development declined in the following areas: United States (−26%), Far East (−22%), Africa (−18%), Australia/New Zealand (−17%), and Europe (−4%). Petroleum expenditures increased in the following areas: South America (+31%), Canada (+24%), Middle East (+22%), and Mexico (+21%). Geophysical activity for petroleum exploration and development declined 14 percent in the Western Hemisphere and 9 percent in the Eastern Hemisphere.

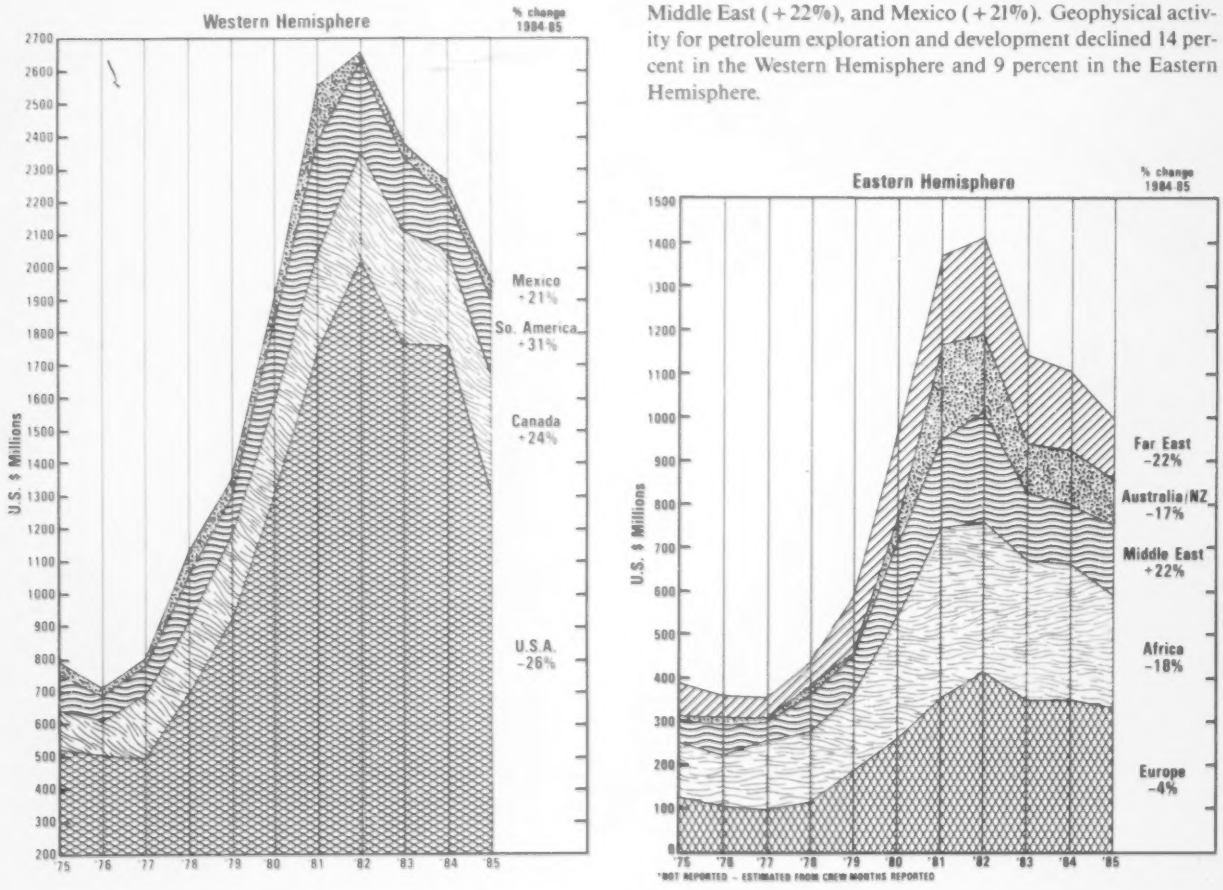

FIG. 1 Total expenditures on petroleum exploration and development, 1975-1985.

Table 2. Total worldwide expenditures in US$ (thousands) by area and survey objective.

Area	Petroleum[1] Exploration	Petroleum[1] Development	Minerals	Environmental	Engineering	Geothermal	Groundwater	Oceanography	Research	Total
International	15,261							4,187	2,721	22,169
U.S.A.	1,269,860	37,771	3,857	3,561	2,249	401	763	1,015	10,275	1,329,752
Canada	362,144	255	8,031	20	725		29	554	2,175	373,933
Mexico	35,048		139						1,360	36,547
South America	233,199	3,352	556		5			2,154	5,034	244,300
Europe	285,369	51,385	1,797	10	2,890	500	29	281	2,421	344,682
Africa	247,980	5,040	6,298		275		828	188	100	260,709
Middle East	161,383		61		100			844		162,388
Far East	131,798	9,070	137		630	370	21		350	142,376
Australia/ New Zealand	97,394	9,047	1,504				6		2,764	110,715
Total	2,839,436	115,920	22,380	3,591	6,873	1,271	1,676	9,223	27,200	3,027,570

[1]Includes processing and interpretation costs for land, marine, and transition zone. See text for details.

A 10-year history of geophysical activity in both the Western and Eastern Hemispheres is shown in Figure 1.

Seismic surveys

The seismic method for petroleum exploration, excluding development activity, accounted for 92 percent of all petroleum acquisition costs. This statistic, plus the strong tendency for exploration drilling and parallel seismic activity to follow, has caused those interested in forecasts of petroleum exploration to regard seismic activity as a barometer for exploration. A 10-year history of the cost of petroleum seismic surveys in both Eastern and Western Hemispheres is shown in Figure 2. In the Western Hemisphere, the acquisition costs per mile of land seismic surveys dropped 24 percent, while marine costs increased 6 percent. In the Eastern Hemisphere, acquisition costs per mile for land seismic decreased 2 percent, while marine costs fell 9 percent.

The total number of miles of seismic data recorded worldwide was up 3 percent on land and down 2 percent in marine work, as shown in Tables 3 and 5 which do not include activity reported for the transition zone. We had an increase of 10,155 miles of seismic worldwide, while the cost per mile showed a decrease

(Text continued on p. 35)

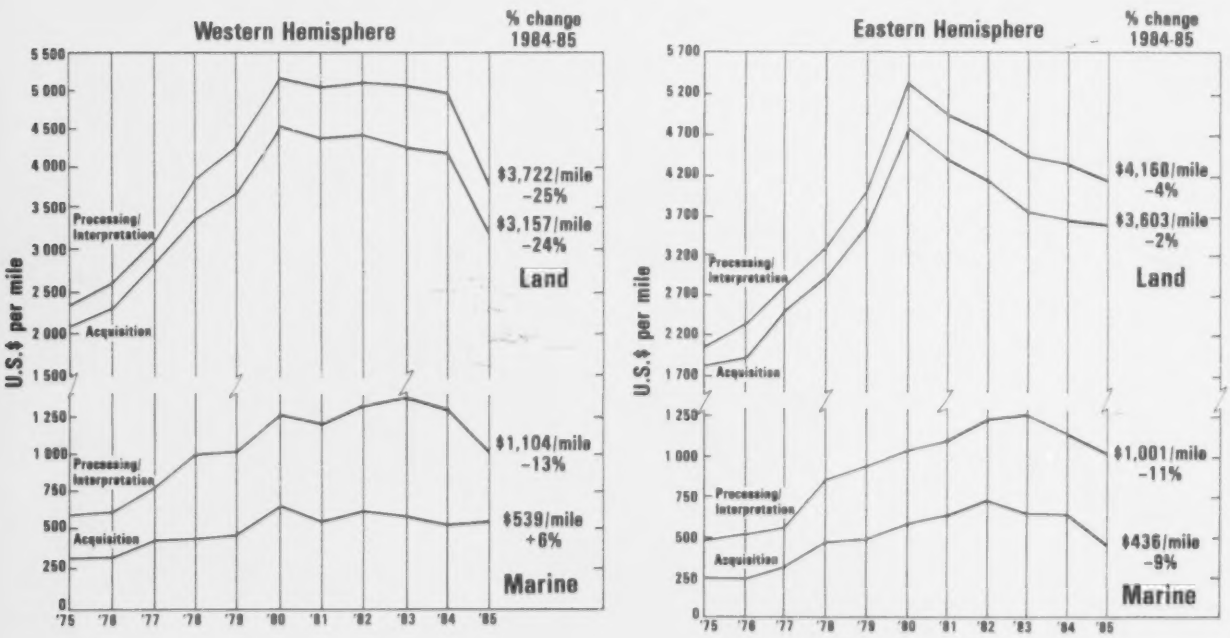

FIG. 2 Average cost per mile for petroleum seismic surveys, 1975-1985.

Table 3. Worldwide petroleum land seismic activity.[1]

Area	Acquisition costs - US$	Line-miles	Crew-months		Crew-months total*	Average miles/month	Average cost/month	Average cost/mile
			Company*	Contract				
U.S.A.	575,901,784	140,047	357.7	2,538.9	2,866.6	49	200,901	4,112
	[3,253,000]	[102]	[1.0]	[17.0]	[18.0]	[5]	[180,722]	[31,798]
Canada	256,428,137	121,434	54.0	812.3	866.3	140	296,004	2,112
	[7,335,000]	[257]		[13.5]	[13.5]	[19]	[543,333]	[28,540]
Mexico	12,313,675	11,241		200.0	200.0	56	61,568	1,095
South America	123,907,490	34,050		468.6	468.6	72	264,420	3,638
Europe	100,335,003	25,810	20.0	482.9	502.9	51	199,512	3,887
	[19,497,503]	[709]		[42.3]	[42.3]	[16]	[460,933]	[27,500]
Africa	151,018,059	40,281	6.5	505.3	511.8	78	295,072	3,749
Middle East	111,599,572	30,617		324.4	324.4	94	344,018	3,645
Far East	67,008,442	18,043		305.0	305.0	59	219,699	3,713
Australia/ New Zealand	51,528,721	18,868		172.0	172.0	109	299,498	2,731
Total	1,450,040,883	440,391	438.2	5,809.5	6,247.7	70	232,092	3,293
	[30,085,503]	[1,068]	[1.0]	[72.8]	[73.8]	[14]	[407,662]	[28,162]

[1]All data enclosed in [brackets] pertain to 3-D surveys reported in square miles.

*Total includes government and university activity, if any.

Table 4. Worldwide petroleum land seismic line-miles by energy source and 3-D surveys.

Area	Dynamite	Compressed air	Weight drop	Solid chemical	Vibrator	Total line-miles	3-D surveys	
							Line-miles	Square miles
U.S.A.	46,077	9,822	411		82,950	139,261	786	102
Canada	54,185	42,448	5,927		18,272	120,834	600	257
Mexico	6,078				5,163	11,241		
South America	19,388				14,662	34,050		
Europe	9,205	50	107		16,448	25,810		709
Africa	13,218		1,120		25,943	40,281		
Middle East	6,599		2,809		21,209	30,617		
Far East	15,099				2,944	18,043		
Australia/ New Zealand	4,491	300		139	13,938	18,868		
Total	174,340	52,620	10,374	139	201,530	439,005	1,386	1,068

Table 5. Worldwide petroleum marine seismic activity.

Area	Acquisition costs - US$	Line-miles	Crew-months		Crew-months total*	Average miles/month	Average cost/month	Average cost/mile
			Company*	Contract				
International	15,261,261	18,698		26.8	26.8	695	567,755	816
U.S.A.	310,355,000	555,076	106.1	440.8	546.9	1,015	567,480	559
Canada	15,769,092	16,753		33.1	33.1	506	476,407	941
Mexico								
South America	32,589,000	93,780	12.0	69.9	81.9	1,145	397,912	347
Europe	83,224,324	184,827	3.6	249.8	253.4	729	328,431	450
Africa	26,428,945	63,384		69.0	69.0	919	383,028	417
Middle East	10,753,000	33,086		23.0	23.0	1,438	467,521	325
Far East	24,448,000	57,210		48.5	48.5	1,179	504,082	427
Australia/ New Zealand	20,716,000	41,226		34.4	34.4	1,198	602,209	502
Total	539,544,622	1,064,040	121.7	995.4	1,117.1	953	482,987	507

*Total includes government and university activity, if any.

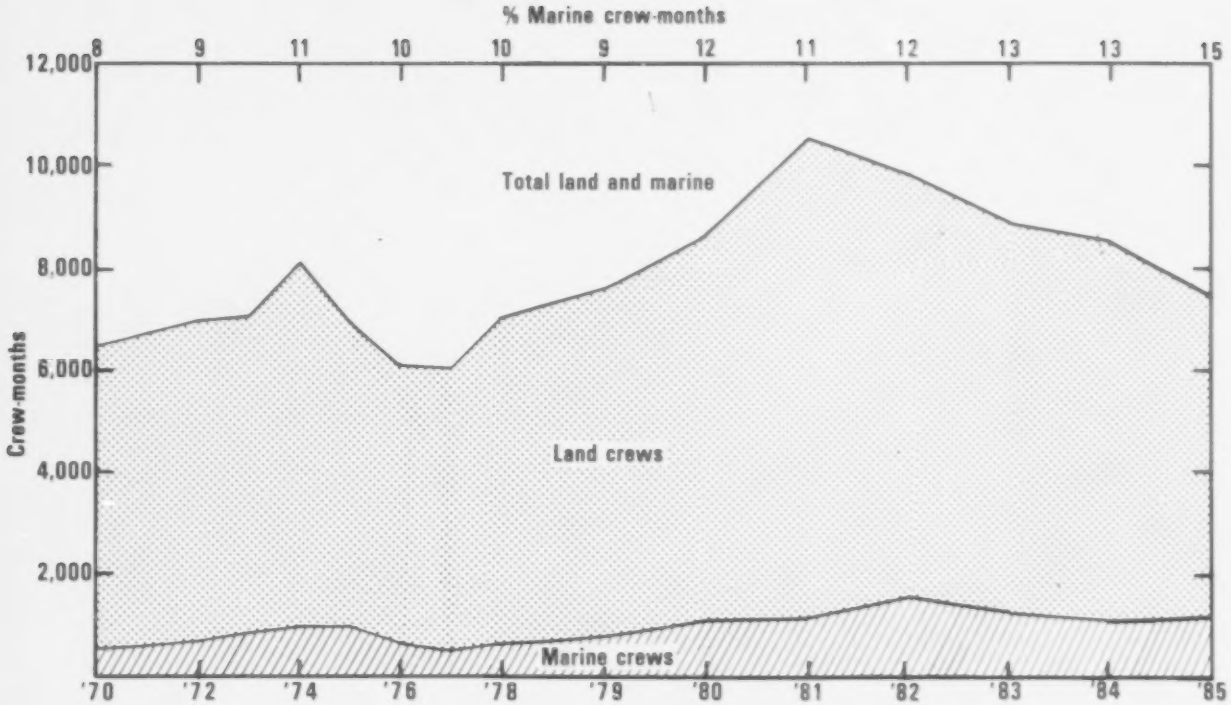

FIG. 3 Worldwide seismic activity in crew-months, 1970-1985.

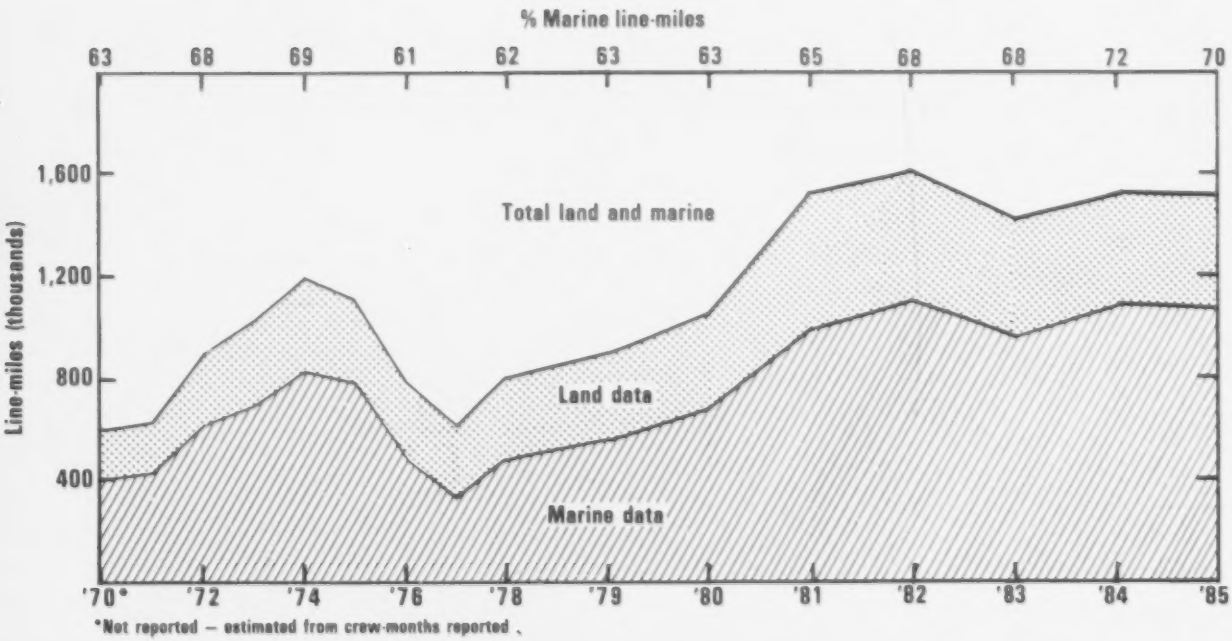
% Marine line-miles
63 68 69 61 62 63 63 65 68 68 72 70
1,600
1,200
800
400
Line-miles (thousands)
Total land and marine
Land data
Marine data
'70* '72 '74 '76 '78 '79 '80 '81 '82 '83 '84 '85
*Not reported – estimated from crew-months reported

FIG. 4 Worldwide seismic activity in line-miles, 1970-1985.

Table 6. Worldwide petroleum marine seismic line-miles by energy source and 3-D surveys.

Area	Compressed air	Electrical	Gas Exploder	Implosive	Total line-miles	3-D surveys	
						Line-miles	Square miles
International	16,586			2,112	18,698		
U.S.A.	552,318				552,318	2,758	
Canada	16,471		282		16,753		
Mexico							
South America	81,780	12,000			93,780		
Europe	150,163	480		15,946	166,589	18,238	
Africa	45,794	530		3,257	49,581	13,803	
Middle East	33,086				33,086		
Far East	57,210				57,210		
Australia/ New Zealand	41,226				41,226		
Total	994,634	13,010	282	21,315	1,029,241	34,799	0

Table 7. Worldwide average unit costs for petroleum surveys.

Area, survey type, and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew-month or man-month*	Average cost/ mile or (foot) or [station]
International						
Marine						
Seismic (*P*-wave)						
Compressed air	23.5	16,586	14,469,261	706	615,713	872
Implosive	3.3	2,112	792,000	625	234,320	375
U.S.A.						
Land						
Seismic (*P*-wave)						
Dynamite	1,221.9	45,568	252,792,913	37	206,877	5,548
Compressed air	152.5	9,822	27,651,439	64	181,214	2,815
Weight drop	17.9	411	1,124,619	23	62,653	2,736
Vibratory	1,472.1	82,852	290,645,443	56	197,433	3,508
Seismic (*S*-wave)						
Dynamite	.6	5	27,370	8	42,108	5,474
Vibratory	2.2	98	734,000	45	333,636	7,490
Seismic (refraction)						
Dynamite	24.0	504	1,200,000	21	50,000	2,381
3-D seismic[1]	23.2	888[1]	4,979,000	38[1]	214,612	5,605[1]
Gravity	.2	40	8,038	161	32,152	200
Gravity	100.0	[55,561]	3,158,486	[556]	31,585	[57]
Gravity	15.0*	[7,243]	289,750	[483]*	19,317*	[40]
Magnetic	7.5	[5,660]	168,000	[755]	22,400	[30]
Electromagnetic						
Time domain	2.1	171	204,500	81	97,381	1,196
Magnetotelluric						
Natural field	34.7	[1,593]	3,057,258	[46]	87,979	[1,919]
Controlled source	1.4	[453]	108,600	[324]	77,571	[240]
Other	1.0	14	100,000	14	100,000	7,143

[1] These 3-D data are a mix of line-miles and square miles. See Table 3 or 5 for exact breakdown.

Table 7. Worldwide averag unit costs for petroleum surveys (cont.).

Area, survey type, and method	Total crew months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
U.S.A., continued						
Transition zone						
Seismic (*P*-wave)						
Dynamite	31.4	1,467	8,587,373	47	273,483	5,853
Compressed air	15.0	563	2,170,000	38	144,667	3,854
Vibratory	3.0	270	2,588,000	90	862,667	9,585
Seismic (*S*-wave)						
Compressed air	1.0	300	120,000	300	120,000	400
Marine						
Seismic (*P*-wave)						
Compressed air	537.9	552,318	307,367,000	1,027	571,378	557
3-D seismic[2]	9.0	2,758[2]	2,988,000	306[2]	332,000	1,083[2]
Gravity	36.5	36,878	1,973,537	1,010	54,070	54
Other	2.0	200	300,000	100	150,000	1,500
Airborne						
Magnetic	60.8	329,914	6,641,008	5,426	109,227	20
Magnetic	5.0	[28,250]	262,500	[5,650]	52,500	[9]
Remote sensing						
Side-looking radar	8	20,000	650,000	25,000	812,500	32
Drill hole						
Gravity	13.0	(82,285)	866,000	(6,330)	66,615	(11)
Sonic/velocity logging	7.7*	(38,500)	315,000	(5,000)*	40,909*	(8)
Canada						
Land						
Seismic (*P*-wave)						
Dynamite	482.6	53,186	173,214,284	110	358,852	3,257
Compressed air	92.3	42,448	25,959,000	460	281,215	612
Weight drop	52.5	5,927	10,964,331	113	208,566	1,850
Vibratory	227.8	18,272	44,274,522	80	194,357	2,423
Seismic (refraction)						
Dynamite	7.0	999	432,000	143	61,714	432
3-D seismic[1]	17.5	857[1]	8,919,000	49[1]	509,657	10,407[1]
Gravity	10.0*	[8,340]	94,000	[834]*	9,400*	[11]
Electromagnetic						
Time domain	2.0	80	200,000	40	100,000	2,500
Magnetotelluric						
Natural field	3.5	[140]	280,000	[40]	80,000	[2,000]
Marine						
Seismic (*P*-wave)						
Compressed air	30.1	16,471	15,427,000	547	512,525	937
Gas exploder	3.0	282	342,092	94	114,031	1,213
Gravity	8.0	2,631	147,000	329	18,375	56
Airborne						
Magnetic	21.0	133,000	3,480,000	6,333	165,714	26
Drill hole						
Vertical seismic prof.	.1	[1]	10,000	[10]	100,000	[10,000]

[1] These 3-D data are a mix of line-miles and square miles. See Table 3 or 5 for exact breakdown.
[2] All these 3-D data reported in line-miles.

Table 7. Worldwide average unit costs for petroleum surveys (cont.).

Area, survey type, and method	Total crew months or man-months*	Miles or (footage) or [stations]	Acquisition costs – US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Mexico						
Land						
Seismic (*P*-wave)						
Dynamite	113.5	6,078	6,732,000	54	59,313	1,108
Vibratory	86.5	5,163	5,581,675	60	64,528	1,081
Gravity	40.0	1,000	123,000	25	3,075	123
Magnetotelluric						
Natural field	24.0	[309]	263,886	[13]	10,995	[854]
Transition zone						
Seismic (*P*-wave)						
Compressed air	17.0	2,694	7,813,000	158	459,588	2,900
Airborne						
Magnetic	13.1	60,510	1,868,000	4,609	142,270	31
Drill hole						
Vertical seismic prof.	12.0	[35]	261,310	[3]	21,776	[7,466]
South America						
Land						
Seismic (*P*-wave)						
Dynamite	266.7	19,388	86,776,490	73	325,371	4,476
Vibratory	201.9	14,662	37,131,000	73	183,908	2,532
Transition zone						
Seismic (*P*-wave)						
Compressed air	12.6	2,064	5,404,001	164	428,889	2,618
Marine						
Seismic (*P*-wave)						
Compressed air	69.9	81,780	31,874,000	1,170	455,994	390
Electrical	12.0	12,000	715,000	1,000	59,583	60
Gravity	2.0	745	60,000	373	30,000	81
Airborne						
Magnetic	8.5	62,240	2,235,000	7,263	260,793	36
Magnetic	3.0	[10,000]	132,000	[3,333]	44,000	[13]
Europe						
Land						
Seismic (*P*-wave)						
Dynamite	234.3	8,205	49,362,331	35	210,680	6,016
Compressed air	3.0	50	300,001	17	100,000	6,000
Weight drop	2.1	107	347,001	51	165,239	3,243
Vibratory	243.5	16,448	48,325,670	68	198,463	2,938
Seismic (refraction)						
Dynamite	20.0	1,000	2,000,000	50	100,000	2,000
3-D seismic[3]	42.3	709[3]	19,497,503	17[3]	460,934	27,500[3]
Gravity	28.0	[25,701]	974,001	[918]	34,786	[38]
Resistivity	1.5	24	18,000	16	12,000	750
Induced polarization						
Frequency domain	4.5	45	202,501	10	45,000	4,490
Transition zone						
Seismic (*P*-wave)						
Dynamite	2.0	25	634,000	13	317,000	25,360
Compressed air	11.2	1,460	3,153,254	130	281,541	2,160
3-D seismic[3]	6.9	81[3]	1,400,000	12[3]	202,899	17,284[3]

[3]All these 3-D data reported in square miles.

Table 7. Worldwide average unit costs for petroleum surveys (cont.).

Area, survey type, and method	Total crew months or man-months*	Miles or (footage) or [stations]	Acquisition costs – US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Europe, continued						
Marine						
Seismic (*P*-wave)						
Compressed air	196.5	150,163	68,849,504	764	350,326	458
Electrical	2.0	480	160,000	240	80,000	333
Implosive	25.5	15,946	5,979,750	625	234,224	375
3-D seismic[2]	29.4	18,238[2]	8,235,070	620[2]	280,104	452[2]
Gravity	8.0	3,727	271,000	466	33,875	73
Airborne						
Magnetic	16.0*	13,150	925,300	822*	57,831*	70
Radiometric						
Gamma ray	14.3	71,564	1,789,100	5,004	125,112	25
Drill hole						
Gravity	.7	(9,047)	95,000	(12,924)	135,714	(11)
Sonic/velocity logging	16.2*	(57,350)	45,862	(3,540)*	2,831*	(1)
Vertical seismic prof.	24.2*	[131]	2,947,500	[5]*	121,798*	[22,500]
Africa						
Land						
Seismic (*P*-wave)						
Dynamite	204.1	13,218	71,636,823	65	350,989	5,420
Weight drop	28.0	1,120	3,763,000	40	134,393	3,360
Vibratory	279.7	25,943	75,618,236	93	270,355	2,915
Gravity	55.7	[59,485]	3,171,500	[1,068]	56,939	[53]
Resistivity	3.0	48	36,000	16	12,000	750
Transition zone						
Seismic (*P*-wave)						
Compressed air	19.0	1,816	4,718,603	96	248,348	2,598
Marine						
Seismic (*P*-wave)						
Compressed air	42.3	45,794	16,154,005	1,083	381,891	353
Electrical	6.0	530	480,000	88	80,000	906
Implosive	5.0	3,257	1,017,250	646	201,835	312
3-D seismic[2]	15.7	13,803[2]	8,777,690	879[2]	559,089	636[2]
Gravity	1.0	1,242	30,000	1,242	30,000	24
Airborne						
Magnetic	16.5	302,350	7,417,000	18,324	449,515	25
Radiometric						
Gamma ray	12.6	63,368	1,584,200	5,009	125,233	25
Drill hole						
Vertical seismic prof.	.4*	[2]	45,000	[5]*	112,500*	[22,500]
Middle East						
Land						
Seismic (*P*-wave)						
Dynamite	94.5	6,599	29,121,760	70	308,167	4,413
Weight drop	36.0	2,809	14,798,691	78	411,075	5,268
Vibratory	193.9	21,209	67,679,121	109	349,041	3,191
Gravity	18.5	[13,715]	594,000	[741]	32,108	[43]

[2]All these 3-D data reported in line-miles.

Table 7. Worldwide average unit costs for petroleum surveys (cont.).

Area, survey type, and method	Total crew months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Middle East, continued						
Transition zone						
Seismic (*P*-wave)						
Compressed air	1.5	449	900,001	299	600,001	2,004
Marine						
Seismic (*P*-wave)						
Compressed air	23.0	33,086	10,753,000	1,439	467,522	325
Airborne						
Magnetic	11.4	65,950	1,319,000	5,785	115,702	20
Drill hole						
Vertical seismic prof.	2.0*	[10]	225,000	[5]*	112,500*	[22,500]
Far East						
Land						
Seismic (*P*-wave)						
Dynamite	261.8	15,099	57,206,442	58	218,512	3,789
Vibratory	43.2	2,944	9,802,000	68	226,898	3,329
Other	8.8	123	880,000	14	100,000	7,154
Transition zone						
Seismic (*P*-wave)						
Compressed air	30.0	1,859	5,110,000	62	170,333	2,749
Marine						
Seismic (*P*-wave)						
Compressed air	48.5	57,210	24,448,000	1,180	504,082	427
Gravity	3.0	1,770	67,000	590	22,333	38
Airborne						
Magnetic	12.5*	6,405	140,910	512*	11,273*	22
Radiometric						
Gamma ray	1.6	8,193	204,825	5,121	128,016	25
Drill hole						
Gravity	.2	(5,714)	60,000	(28,570)	300,000	(11)
Vertical seismic prof.	.4*	[2]	45,000	[5]*	112,500*	[22,500]
Australia/New Zealand						
Land						
Seismic (*P*-wave)						
Dynamite	55.9	4,491	12,324,703	80	220,281	2,744
Compressed air	2.0	300	657,000	150	328,500	2,190
Solid chemical	1.0	139	225,000	139	225,000	1,619
Vibratory	113.1	13,938	38,322,018	123	338,833	2,749
Gravity	7.5	[15,030]	134,500	[2,004]	17,933	[9]
Marine						
Seismic (*P*-wave)						
Compressed air	34.4	41,226	20,716,000	1,198	602,209	502
Gravity	4.5	3,789	108,000	842	24,000	29

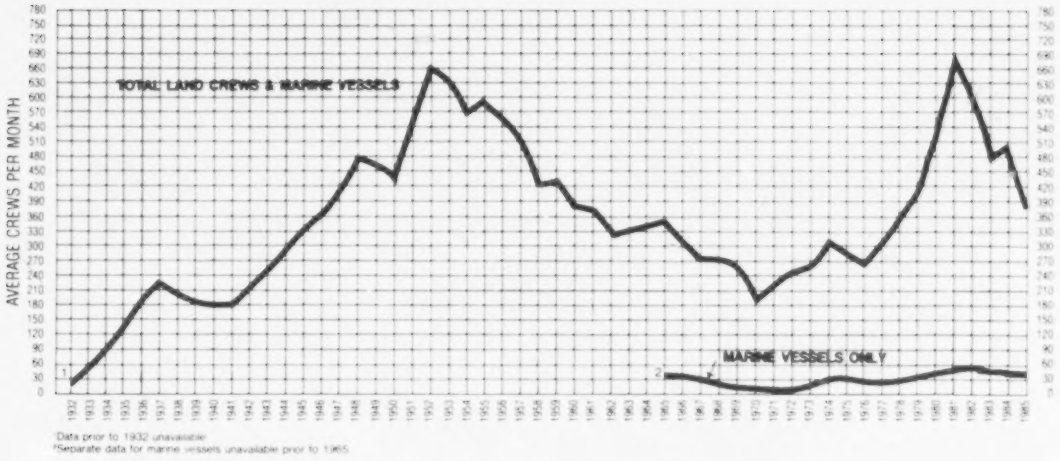
AVERAGE CREWS PER MONTH
TOTAL LAND CREWS & MARINE VESSELS
MARINE VESSELS ONLY
Data prior to 1932 unavailable
*Separate data for marine vessels unavailable prior to 1965

FIG. 5 History of seismic exploration activity in the U.S., 1932-1985. (The total crews working in a given year is not synonymous with the crew-months worked that year.)

in both land and marine seismic surveys. Vibroseis® was the most popular land seismic energy source with dynamite being a close second. Together these two energy sources account for 86 percent of all seismic land work. Air gun (compressed air) as a source accounted for 12 percent of land work, a 97 percent increase over 1984 (see Table 4). In marine work, the compressed air source accounted for 97 percent of total line-miles (see Table 6).

A more comprehensive breakdown of statistical data on petroleum surveys, sorted by geographic area, can be seen in Table 7. Table 8 shows petroleum seismic activity by states in the U.S. Most states showed decreases from 1984. Some of the states with large decreases were Alabama, Arizona, Georgia, Idaho, Iowa, Indiana, Kansas, Louisiana, Montana, Nebraska, New Mexico, Ohio, Oklahoma, Tennessee, Texas, Utah, West Virginia, and Wyoming. No activity at all was reported from the following states that were represented in last year's report: Massachusetts, Maryland, Maine, Vermont, Wisconsin, and South Dakota. The only states showing significant increases were Alaska, California, Florida, Kentucky, Michigan, Minnesota, Missouri, and Pennsylvania. North Carolina is the only state in this year's report that was not listed in 1984. Marine seismic activity in U.S. waters shifted significantly from the East Coast and off Alaska to the Gulf and West Coasts.

Tables 9 and 10 show petroleum seismic activity in Canada and Mexico, respectively.

A 53-year history of seismic exploration in the U.S. is shown in Figure 5. This information is compiled by the SEG Business Office. Data for this graph are gathered monthly by telephone.

Gravity and magnetic surveys

Table 11 shows worldwide expenditures for gravity and magnetic surveys. The 1985 data show a 6 percent increase in the use of these tools as compared to 1984. The petroleum objective was the major contributor with a 15 percent increase in activity, most of which was in the United States.

Airborne surveys

Statistical data on airborne surveys are shown in Tables 12, 13A and 13B. Expenditures for worldwide airborne surveys decreased over 29 percent from 1984. The major decrease was in minerals exploration which decreased 58 percent from the previous year. Magnetic surveys continued to be the most popular; however, radiometric gamma ray was again in 1985 a significant second in the Eastern Hemisphere.

Land mining

Tables 14A and 14B report expenditures and methods utilized for land mining in the Western and Eastern Hemispheres. Reported usage of geophysical exploration for minerals using land methods was up from 1984 for the Western Hemisphere and down for the Eastern Hemisphere. The largest increase was for Canada.

Engineering, geothermal, groundwater, oceanography, and research

Table 15 reports engineering and groundwater activity. Table 16 contains worldwide geothermal work. Average unit costs for all survey objectives, types, and methods can be found in Table 17. Expenditures for groundwater and engineering activity are down 50 percent (Table 15). Geothermal activity is down from the previous year with a decrease in expenditures of 20 percent. Oceanography costs increased slightly in marine and decreased in airborne methods. Research for marine was up with the most significant increases listed for the United States and South America. Geographic distribution of these expenditures is given in Table 2.

(Text continued on p. 40)

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Table 8. U.S.A. petroleum seismic activity by area[1].

Survey type, state	Acquisition costs - US$	Line-miles	Crew-months		Crew-months total*
			Company*	Contract	
Land					
Undesignated	3,388,001	2,940	.0	14.0	14.0
Alaska	47,953,000	5,941	.0	47.8	47.8
Alabama	14,918,069	3,263	16.2	61.3	77.5
Arkansas	12,259,326	2,434	8.4	49.0	57.4
Arizona	747,000	240	.0	4.0	4.0
California	26,556,000	7,488	15.5	133.1	148.6
	[1,594,000]	[58]		[9.0]	[9.0]
Colorado	25,812,803	6,562	14.0	117.1	131.1
	[296,000]	[10]		[2.0]	[2.0]
Florida	3,945,294	784	2.5	15.5	18.0
Georgia	187,000	100	.0	2.0	2.0
Iowa	2,311,000	645	.0	10.0	10.0
Idaho	1,162,000	151	2.0	2.0	4.0
Illinois	1,407,000	609	.0	11.1	11.1
Indiana	573,000	206	.0	3.2	3.2
Kansas	8,560,561	2,463	7.3	62.0	69.3
Kentucky	785,000	286	.0	3.4	3.4
Louisiana	65,048,710	10,361	55.4	224.7	280.1
Michigan	43,722,990	9,727	38.0	202.5	240.5
Minnesota	1,027,000	284	.0	7.0	7.0
Missouri	360,000	128	.0	3.0	3.0
Mississippi	18,369,870	2,935	20.3	57.1	77.5
	[133,000]	[4]		[.7]	[.7]
Montana	10,011,727	2,166	3.4	39.5	42.9
	[260,000]	[10]	[1.0]		[1.0]
North Carolina	1,641,000	643	.0	12.0	12.0
North Dakota	13,863,874	4,063	12.0	67.0	79.0
Nebraska	1,083,890	420	.0	7.6	7.6
New Mexico	13,638,978	3,434	12.5	50.3	62.8
Nevada	9,112,490	2,339	1.0	59.4	60.4
	[146,000]	[5]		[1.0]	[1.0]
New York	1,690,000	466	.0	8.7	8.7
Ohio	956,000	279	.0	8.5	8.5
Oklahoma	31,889,756	7,674	18.0	184.0	202.0
Oregon	4,228,000	936	.0	19.0	19.0
Pennsylvania	2,795,000	819	.0	17.0	17.0
Tennessee	916,000	156	.0	3.6	3.6
Texas	153,653,813	44,476	98.1	834.1	932.2
	[824,000]	[15]		[4.2]	[4.2]
Utah	10,679,186	4,393	1.8	27.0	28.8
Virginia	1,023,000	260	1.0	4.8	5.8
Washington	5,822,000	1,507	12.0	17.7	29.7
West Virginia	726,000	83	.0	3.7	3.7
Wyoming	33,077,446	8,380	18.0	144.6	162.6
Total land	575,901,784	140,047	357.7	2,538.9	2,896.6
	[3,253,000]	[102]	[1.0]	[17.0]	[18.0]
Transition					
Gulf Coast	9,512,373	1,860	6.3	29.1	35.4
Off Alaska	2,588,000	270	.0	3.0	3.0
West Coast	1,365,000	470	.0	12.0	12.0
Total transition	13,465,373	2,600	6.3	44.1	50.4

[1] All data enclosed in [brackets] pertain to 3-D surveys reported in square miles.
*Total includes government and university activity, if any.

Table 8. U.S.A. petroleum seismic activity by area[1] (cont.).

Survey type, state	Acquisition costs - US$	Line-miles	Crew-months		Crew-months total*
			Company*	Contract	
Marine					
East Coast	1,190,000	2,102	.0	4.0	4.0
Gulf Coast	270,653,000	476,100	106.1	387.3	493.4
Off Alaska	2,681,000	5,538	.0	10.0	10.0
West Coast	35,831,000	71,336	.0	39.5	39.5
Total Marine	310,355,000	555,076	106.1	440.8	546.9
Total U.S.A.	899,725,157	697,723	470.1	3,023.8	3,494.0
	[3,253,000]	[102]	[1.0]	[17.0]	[18.0]

[1]All data enclosed in [brackets] pertain to 3-D surveys reported in square miles.
*Total includes government and university activity, if any.

Table 9. Canada petroleum seismic activity by area[1].

Survey type, province	Acquisition costs - US$	Line-miles	Crew-months		Crew-months total*
			Company*	Contract	
Land					
Undesignated	5,729,000	2,190	.0	47.0	47.0
	[2,335,000]	[85]		[6.0]	[6.0]
Alberta	183,561,978	96,979	44.5	581.6	626.1
	[5,000,000]	[172]		[7.5]	[7.5]
British Columbia	11,310,355	2,998	.0	29.1	29.1
Manitoba	1,786,695	1,110	.0	6.7	6.7
Northwest Territiories	26,796,575	4,486	.0	41.6	41.6
Ontario	967,000	457	.0	9.7	9.7
Quebec	252,000	124	6.0	.0	6.0
Saskatchewan	22,524,534	12,758	3.5	93.5	97.0
Yukon	3,500,000	330	.0	3.0	3.0
Total land	256,428,137	121,434	54.0	812.3	866.3
	[7,335,000]	[257]		[13.5]	[13.5]
Marine					
East Coast	15,427,000	16,471	.0	30.1	30.1
Northwest Territories	342,092	282	.0	3.0	3.0
Total Marine	15,769,092	16,753	.0	33.1	33.1
Total Canada	272,197,229	138,187	54.0	845.4	899.4
	[7,335,000]	[257]		[13.5]	[13.5]

[1]All data enclosed in [brackets] pertain to 3-D surveys reported in square miles.
*Total includes government and university activity, if any.

Table 10. Petroleum seismic activity in Mexico.

Survey type	Acquisition costs - US$	Line-miles	Crew-months		Total months
			Company*	Contract	
Land					
Various	12,313,675	11,241	.0	200.0	200.0
Transition zone					
Various	7,813,000	2,694	.0	17.0	17.0
Total Mexico	20,126,675	13,935	.0	217.0	217.0

Table 11. Total worldwide expenditures on gravity and magnetic surveys in US$ (thousands).

Area	Petroleum exploration	Minerals	Environmental	Engineering	Geothermal	Groundwater	Oceanography	Research	Total
International							341	2,022	2,364
U.S.A.	13,367	851	63	6	20	53		1,468	15,830
Canada	3,721	1,394						393	5,508
Mexico	1,991	73						1,360	3,424
South America	2,427			4			1,600	1,000	5,031
Europe	2,265	15		100		19		8	2,407
Africa	10,618	1,657				674			12,950
Middle East	1,913	1							268
Far East	267	1							
Australia/ New Zealand	242	753				6		863	1,865
Total	36,813	4,748	63	110	20	753	1,941	7,116	51,567

Table 12. Total worldwide expenditures on airborne surveys in US$ (thousands).

Area	Petroleum exploration	Minerals	Environmental	Oceanography	Research	Total
International				341	178	519
U.S.A.	7,553	928			1,448	9,931
Canada	3,480	4,667			430	8,577
Mexico	1,868	50				1,918
South America	2,367	480		1,600		4,447
Europe	2,714	292	10		12	3,029
Africa	9,001	1,687				10,688
Middle East	1,319					1,319
Far East	345					345
Australia/ New Zealand		1,045			828	1,873
Total	28,648	9,150	10	1,941	2,898	42,649

Table 13A. Western Hemisphere airborne activity in US$ (thousands).

	International		USA		Canada		Mexico		South America	
Survey method	Line-miles [stations]	Cost	Line-miles [stations]	Cost	Line-miles [stations]	Cost	Line-miles [stations]	Cost	Line-miles [stations]	Cost
Gravity									[100,000]	1,600
Magnetic	42,795	519	417,754	7,545	204,214	4,951	73,510	1,918	62,240	2,235
Magnetic			[28,250]	262					[10,000]	132
Electromagnetic										
Frequency domain			500	90	100	40				
Combined EM/Mag.										
Time domain			1,690	181	29,390	653			5,934	480
Frequency domain					23,970	1,995				
VLF			24,000	1,200						
Radiometric										
Gamma ray					21,350	340				
Remote sensing										
Multispectral scanning			222	2						
Side-scan radar			20,000	650						
Other					6,473	598				
Total	42,795	519	464,166 [28,250]	9,931	285,497	8,577	73,510	1,918	68,174 [110,000]	4,447

Table 13B. Eastern Hemisphere airborne activity in US$ (thousands).

Survey method	Europe		Africa		Middle East		Far East		Australia/New Zealand	
	Line-miles [stations]	Cost	Line-miles [stations]	Cost	Line-miles [stations]	Cost	Line-miles [stations]	Cost	Line-miles [stations]	Cost
Magnetic	13,150	925	344,292	8,920	65,950	1,319	6,405	140	178,650	1,428
Combined EM/Mag.										
Time domain	500	40							7,000	445
Frequency domain	3,000	150								
VLF			2,411	120						
Radiometric										
Gamma ray	75,793	1,873	66,560	1,648			8,193	204		
Remote sensing										
Multispectral scanning	2,310	27								
Multispectral scanning	[36]	12								
Total	94,753 [36]	3,029	413,263	10,688	65,950	1,319	14,598	345	185,650	1,873

Table 14A. Western Hemisphere land mining activity in US$ (thousands).

Survey method	International		USA		Canada		Mexico		South America	
	Line-miles [stations]	Cost	Line-miles [stations]	Cost	Line-miles [stations]	Cost	Line-miles [stations]	Cost	Line-miles [stations]	Cost
Seismic (*P*-wave)										
Dynamite			12	104	100	300				
Weight drop					18	25				
Other			2	1						
Seismic (*S*-wave)										
Dynamite							2	4		
Seismic (refraction)										
Dynamite			19	161						
Weight drop			15	15						
Solid chemical			2	4						
Gravity			15	27			55	12		
Gravity			[1,997]	22	[9,400]	56				
Magnetic			302	54	2,234	239	238	11		
Resistivity			25	18	10	3	56	11		
Electromagnetic										
Time domain			69	67	84	61				
Frequency domain			160	29	1,823	529				
VLF			44	18	1,030	196				
Combined EM/Mag.										
Time domain			4	1			3	1		
Frequency domain			22	8	1,532	744				
VLF			5	5	210	74				
Induced polarization										
Time domain			146	105	362	308	11	2		
Frequency domain					50	58				
Complex resistivity			70	85	423	472			40	70
Magnetotelluric										
Natural field			[42]	126						
Controlled source					80	113	10	46		
Controlled source			[440]	86						
Radiometric										
Gamma ray					[1,000]	35				
Other			147	36	125	20			4	6
Total			1,059 [2,479]	980	8,081 [10,400]	3,239	375	89	44	76

Table 14B. Eastern Hemisphere land mining activity in US$ (thousands).

	Europe		Africa		Middle East		Far East		Australia/New Zealand	
Survey method	Line-miles [stations]	Cost	Line-miles [stations]	Cost	Line-miles [stations]	Cost	Line-miles [stations]	Cost	Line-miles [stations]	Cost
Seismic (*P*-wave)										
Dynamite	92	1,281								
Vibratory			1,285	4,193						
Seismic (refraction)										
Dynamite							2	2		
Gravity			465	8					100	150
Gravity	[500]	15	[1,927]	20	[97]	1			[200]	3
Magnetic			1,552	126			3	1		
Resistivity	275	38	105	53						
Self-potential			2	1						
Electromagnetic										
Time domain	133	109	466	82					225	200
Frequency domain			192	24						
VLF			75	6						
Combined EM/Mag.										
Time domain			15	3						
VLF							14	2		
Induced polarization										
Time domain			125	69			7	30	140	105
Magnetotelluric										
Natural field	[16]	48								
Controlled source							[400]	100		
Radiometric										
Gamma ray			407	13						
Other	40	12								
Total	540	1,504	4,689	4,601			26	136	465	458
	[516]		[1,927]		[97]	1	[400]		[200]	

Activity reporting on new methods

Reporting on vertical seismic profiling (VSP) and 3-D seismic methods and transition activity was insufficient to include in the 1984 report. Although the Committee still agrees that the information supplied this year is not complete, it has been included in the tables for the 1985 report in order to have a historical published report of the data for comparison in future years.

Under-reporting is still evident for the VSP method. This is especially true in the region of the United States where no VSPs were reported as being performed. A total of 181 VSPs were listed worldwide: 145 marine surveys and 36 land surveys. Information for these data are compiled in Tables 7 and 17.

Transition zone survey data are shown in Tables 1, 7, and 17. In this new survey type, the major activity was petroleum work with 12,967 line-miles and 81 square miles of seismic activity reported, requiring 156 crew months and $42,600,000 for acquisition. See Table 17 for details of all transition zone work.

Tables 4, 6, 7, and 17 list the information reported on 3-D surveys. Confusion existed on how to report these data this year, as the questionnaires received listed 3-D surveys in both linear miles and square miles. These replies were 1,386 linear and 1,068 square miles shown for land, 81 square miles for transition zone, and 34,799 linear miles reported for marine work worldwide.

Petroleum geophysical activity was divided into two categories, exploration and development, which are listed in Tables 1, 2, and 17. Four percent of all petroleum geophysical dollars spent in 1985 was for development. Eighteen percent of expenditures for petroleum geophysics in Europe was in the area of development.

Summary

Expenditures continued to decline in 1985 for use of geophysics in the petroleum area worldwide. Only the geographic areas of Canada, Mexico, South America, and the Middle East showed an increase in expenditures for petroleum geophysics. Activity in mining, engineering, and geothermal decreased as well. A higher percentage of those surveyed returned their forms this year but there continues to be some companies that decline to return the survey questionnaires for reasons which vary from staff reductions to concerns about confidentiality. It is also true that many firms which contributed data in past years are no longer in existence. The Committee will continue to encourage more complete reporting and monitor new and changing trends in the geophysical activities of the industry.

Acknowledgments

This report was made possible through the contributions of statistical data by companies, contractors, governmental agencies, and universities. For many of these organizations, compilation of these data was a long and tedious task. The Geophysical Activity Committee expresses sincere appreciation to all of those

(Text continued on p. 48)

Table 15. Worldwide groundwater and engineering activity.

Survey method	Area			Time		Cost
	Line-miles	Stations	Footage	Crew-months	Man-months	US$ (thousands)
Seismic (*P*-wave)						
Dynamite	125			4.2		152.5
Compressed air	2,605			6.0		1,250.0
Electrical	6,507			34.6		2,762.5
Gas exploder	440			7.3		724.0
Weight drop	35			3.4	6.5	78.1
Other	61			.5	1.5	41.5
Seismic (*S*-wave)						
Dynamite	2			.2		5.0
Seismic (refraction)						
Dynamite	183	175		23.5		570.3
Weight drop	1,272	800		12.0	19.8	202.7
Solid chemical	64			11.3		204.2
Passive monitoring	1			.5		2.0
Gravity		25,134		37.0	2.0	811.0
Magnetic	220	2,821		1.3	2.0	53.1
Resistivity	347	649	150,413	71.8	7.0	669.3
Self-potential	7		109,592	14.8	1.5	69.8
Sonic/velocity logging			14,986		8.5	48.4
Electromagnetic						
Time domain	67	16		1.5	1.0	43.8
Combined EM/Mag.						
Time domain	300			3.0		18.0
Induced polarization						
Time domain		21			3.0	1.0
Complex resistivity	5			.5		2.5
Magnetotelluric						
Natural field		24		1.0		75.0
Controlled source	5			.5		2.5
Radiometric						
Gamma ray			149,176	15.1	1.0	57.8
Remote sensing						
Other	2				1.0	20.0
Temperature gradient		4,702	2,500		4.9	24.5
Other	282	17,067	19,591	8.6	91.3	659.8
Total	12,534	51,409	446,258	259.1	151.1	8,549.6

Table 16. Worldwide geothermal activity.

Survey method	Area		Time		Cost
	Line-miles	Stations	Crew-months	Man-months	US$ (thousands)
Seismic (refraction)					
Dynamite	50			10.0	500.0
Gravity		500	1.0		20.0
Resistivity	90		2.5		50.0
Electromagnetic					
Time domain		10		2.0	50.0
Magnetotelluric					
Natural field		153	4.5		283.9
Controlled source		646	3.8		292.4
Other		13	3.5		75.0
Total	140	1,322	15.3	12.0	1,271.3

Table 17. Worldwide average unit costs by survey objective, type, and method.

Survey objective, type, and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs – US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew-month or man-month*	Average cost/mile or (foot) or [station]
Petroleum Exploration						
Land						
Seismic (*P*-wave)						
Dynamite	2,931.4	171,737	737,682,746	59	251,641	4,295
Compressed air	249.9	52,620	54,567,440	211	218,357	1,037
Weight drop	136.6	10,374	30,997,642	76	226,889	2,988
Solid chemical	1.0	139	225,000	139	225,000	1,619
Vibratory	2,852.2	201,065	615,254,685	70	215,711	3,060
Seismic (*S*-wave)						
Dynamite	.6	5	27,370	8	42,108	5,474
Vibratory	2.2	98	734,000	45	333,636	7,490
Seismic (refraction)						
Dynamite	51.0	2,503	3,632,000	49	71,216	1,451
3-D Seismic[1]	34.7	1,716[1]	12,681,000	49[1]	365,447	7,390[1]
Gravity	40.2	1,040	131,038	26	3,256	126
Gravity	209.7	[169,492]	8,032,487	[808]	38,305	[47]
Gravity	25.5*	[15,583]	383,750	[623]*	15,350*	[25]
Magnetic	7.5	[5,660]	168,000	[755]	22,400	[30]
Resistivity	4.5	72	54,000	16	12,000	750
Electromagnetic						
Time domain	2.1	171	204,500	81	97,381	1,196
Induced polarization						
Frequency domain	4.5	45	202,501	10	45,000	4,490
Magnetotelluric						
Natural field	62.2	[2,042]	3,601,144	[33]	57,850	[1,764]
Controlled source	1.4	[453]	108,600	[324]	77,571	[240]
Other	9.8	137	980,000	14	100,000	7,153
Transition zone						
Seismic (*P*-wave)						
Dynamite	33.4	1,492	9,221,373	45	276,089	6,180
Compressed air	106.3	10,905	29,268,859	103	275,342	2,684
Vibratory	3.0	270	2,588,000	90	862,667	9,585
Marine						
Seismic (*P*-wave)						
Compressed air	926.1	938,520	470,976,870	1,013	508,521	502
Gas exploder	3.0	282	342,092	94	114,031	1,213
Implosive	33.9	21,315	7,789,000	628	229,426	365
3-D seismic[2]	39.6	27,979[2]	11,569,680	707[2]	292,164	414[2]
Gravity	63.0	50,782	2,656,537	806	42,167	52
Airborne						
Magnetic	131.4	953,964	22,960,008	7,260	174,734	24
Magnetic	8.0	[38,250]	394,500	[4,781]	49,313	[10]
Magnetic	28.5*	19,555	1,066,210	686*	37,411*	55
Radiometric						
Gamma ray	28.5	143,125	3,578,125	5,013	125,328	25
Remote sensing						
Side-scan radar	.8	20,000	650,000	25,000	812,500	32
Drill hole						
Gravity	13.9	(97,046)	1,021,000	(6,982)	73,453	(11)
Sonic/velocity logging	7.7*	(38,500)	315,000	(5,000)*	40,909*	(8)
Vertical seismic prof.	12.1	[36]	271,310	[3]	22,422	[7,536]
Vertical seismic prof.	14.8*	[80]	1,800,000	[5]*	121,622*	[22,500]

[1]These 3-D data are a mix of line-miles and square miles. See Table 3 or 5 for exact breakdown.
[2]All these 3-D data reported in line-miles.

Table 17. Worldwide average unit costs by survey objective, type, and method (cont.).

Survey objective, type, and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs – US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Petroleum development						
Land						
Seismic (*P*-wave)						
Dynamite	4.0	95	1,485,000	24	371,250	15,632
Vibratory	9.5	367	2,125,000	39	223,684	5,790
3-D seismic[3]	48.3	738[3]	20,714,503	15[3]	428,872	28,057[3]
Electromagnetic						
Time domain	2.0	80	200,000	40	100,000	2,500
Transition zone						
Seismic (*S*-wave)						
Compressed air	1.0	300	120,000	300	120,000	400
3-D seismic[3]	6.9	81[3]	1,400,000	12[3]	202,899	17,284[3]
Marine						
Seismic (*P*-wave)						
Compressed air	80.0	56,114	39,080,900	701	488,511	696
Electrical	20.0	13.010	1,355,000	651	67,750	104
3-D seismic[2]	14.5	6,820[2]	8,431,080	470[2]	581,454	1,236[2]
Other	2.0	200	300,000	100	150,000	1,500
Drill hole						
Sonic/velocity logging	16.2*	(57,350)	45,862	(3,540)*	2,831*	(1)
Vertical seismic prof.	12.2*	[65]	1,462,500	[5]*	119,877*	[22,500]
Minerals						
Land						
Seismic (*P*-wave)						
Dynamite	14.9	204	1,685,981	14	112,775	8,240
Weight drop	1.3	18	26,100	14	20,077	1,388
Vibratory	21.0	1,285	4,193,620	61	199,696	3,264
Other	2.0*	2	1,000	1*	500*	500
Seismic (*S*-wave)						
Dynamite	1.0	2	4,000	2	4,000	2,000
Seismic (refraction)						
Dynamite	6.0	23	163,750	4	27,066	7,058
Weight drop	.5	15	15,000	30	30,000	1,000
Solid chemical	1.0	2	4,725	2	4,725	2,054
Gravity	7.4	635	198,591	86	26,764	313
Gravity	13.8	[6,496]	82,035	[471]	5,945	[13]
Gravity	6.0*	[7,625]	37,192	[1,271]*	6,199*	[5]
Magnetic	60.0	3,874	365,877	65	6,098	94
Magnetic	7.5*	455	66,786	61*	8,905*	147
Resistivity	26.5	472	125,298	18	4,719	265
Self-potential	.1	2	1,000	20	10,000	500
Electromagnetic						
Time domain	37.8	977	520,713	26	13,754	533
Frequency domain	31.1	1,942	519,900	62	16,690	268
Frequency domain	6.0*	233	63,749	39*	10,625*	274
VLF	16.8	824	187,621	49	11,141	228
VLF	6.5*	325	34,240	50*	5,268*	105
Combined EM/Mag.						
Time domain	2.0	22	5,300	11	2,650	237
Frequency domain	41.9	1,554	752,958	37	17,970	484
VLF	6.2	229	82,060	37	13,235	358

[2]All these 3-D data reported in line-miles.
[3]All these 3-D data reported in square miles.

Table 17. Worldwide average unit costs by survey objective, type, and method (cont.).

Survey objective, type, and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Minerals, Land, continued						
Induced polarization						
Time domain	67.7	791	621,865	12	9,176	786
Frequency domain	2.0	50	58,600	25	29,300	1,172
Complex resistivity	30.5	533	628,000	17	20,590	1,178
Magnetotelluric						
Natural field	7.5*	[58]	174,000	[8]*	23,200*	[3,000]
Controlled source	7.0	90	159,500	13	22,786	1,772
Controlled source	4.4	[840]	186,000	[191]	42,273	[221]
Radiometric						
Gamma ray	2.5	407	13,000	163	5,200	32
Gamma ray	2.0	[1,000]	35,000	[500]	17,500	[35]
Other	13.4	318	74,845	24	5,573	235
Marine						
Seismic (*P*-wave)						
Electrical	2.0	1,000	620,000	500	310,000	620
Other	43.0*	16,734	1,320,000	389*	30,698*	79
Airborne						
Magnetic	47.8	237,561	3,980,050	4,965	83,173	17
Combined EM/Mag.						
Time domain	21.1	44,514	1,799,000	2,103	84,979	40
Frequency domain	19.5	26,970	2,145,000	1,383	110,000	80
VLF	1.0	2,411	120,550	2,411	120,550	50
Radiometric						
Gamma ray	7.3	28,271	478,420	3,873	65,537	17
Remote sensing						
Multispectral scanning	1.0*	2,462	29,544	2,345*	28,137*	12
Other	4.5	6,473	598,000	1,438	132,889	92
Drill hole						
Magnetic	6.0*	(18,000)	18,000	(3,000)*	3,000*	(1)
Resistivity	6.3*	(27,620)	18,500	(4,384)*	2,937*	(1)
Self-potential	12.3*	(47,620)	78,500	(3,872)*	6,392*	(2)
Electromagnetic						
Time domain	3.2*	(24,500)	19,400	(7,656)*	6,063*	(1)
Induced polarization						
Time domain	.1	(1,300)	970	(11,818)	8,818	(1)
Radiometric						
Gamma ray	6.4*	(24,552)	26,090	(3,836)*	4,077*	(1)
Temperature gradient	12.0*	(45,000)	36,000	(3,750)*	3,000*	(1)
Other	.5*	(2,994)	3,696	(5,988)*	7,392*	(1)
Environmental						
Land						
Seismic (refraction)						
Weight drop	.2*	1	400	1*	2,000*	4,000
Magnetic	2.1	11	57,300	5	27,286	4,983
Magnetic	1.0	[10]	1,000	[10]	1,000	[100]
Magnetic	1.0*	[725]	5,000	[725]*	5,000*	[7]
Resistivity	1.0	120	60,000	120	60,000	500
Resistivity	5.0	[620]	95,500	[123]	18,911	[154]
Self-potential	.3	4	32,240	16	107,467	6,860
Self-potential	4.2*	[13,950]	33,000	[3,321]*	7,857*	[2]
Electromagnetic						
Frequency domain	4.1	135	107,500	33	26,220	796

Table 17. Worldwide average unit costs by survey objective, type, and method (cont.).

Survey objective, type, and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Environmental, Land, continued						
Induced polarization						
Time domain	1.0	15	51,900	15	51,900	3,392
Magnetotelluric						
Controlled source	1.3	[1,318]	70,900	[1,014]	54,538	[54]
Radiometric						
Gamma ray	200.0*	[900]	3,000,000	[5]*	15,000*	[3,333]
Remote sensing						
Other	.2	1	2,200	4	8,800	2,200
Other	.4	6	12,000	15	30,000	2,000
Airborne						
Radiometric						
Gamma ray	.2	500	10,000	2,000	40,000	20
Drill hole						
Sonic/velocity logging	1.6	(7,500)	10,000	(4,688)	6,250	(1)
Radiometric						
Gamma ray	1.2*	(6,408)	9,867	(5,126)*	7,894*	(2)
Other	1.3*	(8,125)	32,500	(6,250)*	25,000*	(4)
Engineering						
Land						
Seismic (*P*-wave)						
Dynamite	2.2	25	122,500	11	54,444	4,900
Electrical	.5	4	6,000	8	12,000	1,500
Weight drop	3.4	32	75,000	9	21,739	2,308
Seismic (refraction)						
Dynamite	18.0	183	559,300	10	31,072	3,048
Weight drop	6.0	11	50,400	2	8,400	4,421
Weight drop	4.0*	[800]	80,000	[200]*	20,000*	[100]
Solid chemical	4.3	8	99,250	2	22,816	11,815
Passive monitoring	.5	1	2,000	2	4,000	2,000
Gravity	7.5	[4,000]	100,000	[533]	13,333	[25]
Magnetic	1.1	120	6,100	104	5,304	51
Resistivity	7.7	36	49,000	5	6,364	1,354
Resistivity	4.5*	13	19,790	3*	4,340*	1,477
Self-potential	1.5	5	20,001	3	13,334	3,922
Self-potential	1.5*	2	9,000	2*	6,000*	3,462
Electromagnetic						
Time domain	1.0*	[16]	4,000	[16]*	4,000*	[250]
Remote sensing						
Other	1.0*	2	20,000	2*	20,000*	10,000
Other	2.5	216	81,500	86	32,600	377
Other	1.5*	6	13,820	4*	8,803*	2,003
Transition zone						
Seismic (*P*-wave)						
Electrical	.2	200	16,000	1,000	80,000	80
Marine						
Seismic (*P*-wave)						
Dynamite	2.0	100	30,000	50	15,000	300
Compressed air	6.0	2,605	1,250,000	434	208,333	480
Electrical	28.9	6,103	2,665,500	211	92,073	437
Gas exploder	7.3	440	724,000	60	98,503	1,645
Other	.5	60	40,000	120	80,000	667

Table 17. Worldwide average unit costs by survey objective, type, and method (cont.).

Survey objective, type, and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Engineering, Marine, continued						
Magnetic	.2	100	4,700	500	23,500	47
Resistivity	2.5*	20	220,000	8*	88,000*	11,000
Other	1.0	50	100,000	50	100,000	2,000
Drill hole						
Sonic/velocity logging	8.5*	(14,986)	48,482	(1,763)*	5,704*	(3)
Radiometric						
Gamma ray	1.0*	(3,000)	16,000	(3,000)*	16,000*	(5)
Temperature gradient	4.7*	[4,702]	23,502	[1,000]*	5,000*	[5]
Other	1.0	(4,200)	52,500	(4,200)	52,500	(13)
Other	85.3*	[17,067]	341,207	[200]*	4,000*	[20]
Other	3.5*	(6,941)	23,833	(1,983)*	6,809*	(3)
Geothermal						
Land						
Seismic (refraction)						
Dynamite	10.0*	50	500,000	5*	50,000*	10,000
Gravity	1.0	[500]	20,000	[500]	20,000	[40]
Resistivity	2.5	90	50,000	36	20,000	556
Electromagnetic						
Time domain	2.0*	[10]	50,000	[5]*	25,000*	[5,000]
Magnetotelluric						
Natural field	4.5	[153]	283,983	[34]	63,107	[1,856]
Controlled source	3.8	[646]	292,400	[170]	76,947	[453]
Other	3.5	[13]	75,000	[4]	21,429	[5,769]
Groundwater						
Land						
Seismic (*P*-wave)						
Electrical	5.0	200	75,000	40	15,000	375
Weight drop	6.5*	3	3,100	1*	477*	1,000
Other	1.5*	1	1,500	1*	1,000*	882
Seismic (*S*-wave)						
Dynamite	.2	2	5,000	8	20,000	2,500
Seismic (refraction)						
Dynamite	5.5	[175]	11,000	[32]	2,000	[63]
Weight drop	6.0	1,242	2,200	207	367	2
Weight drop	15.8*	18	70,125	1*	4,438*	3,750
Solid chemical	7.0	56	105,000	8	15,000	1,875
Gravity	29.5	[20,680]	699,700	[701]	23,719	[34]
Gravity	2.0*	[454]	11,350	[227]*	5,675*	[25]
Magnetic	2.0*	[2,821]	42,315	[1,411]*	21,158*	[15]
Resistivity	23.1	277	77,175	12	3,337	278
Resistivity	17.2	[649]	171,803	[38]	9,989	[265]
Electromagnetic						
Time domain	1.5	67	39,800	43	25,677	594
Combined EM/Mag.						
Time domain	3.0	300	18,000	100	6,000	60
Induced polarization						
Time domain	3.0*	[21]	1,050	[7]*	350*	[50]
Complex resistivity	.5	5	2,500	10	5,000	500
Magnetotelluric						
Natural field	1.0	[24]	75,000	[24]	75,000	[3,125]
Controlled source	.5	5	2,500	10	5,000	500
Other	1.0	10	10,000	10	10,000	1,000

Table 17. Worldwide average unit costs by survey objective, type, and method (cont.).

Survey objective, type, and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Groundwater, continued						
Drill hole						
Resistivity	23.8	(150,413)	131,565	(6,304)	5,514	(1)
Self-potential	13.3	(109,592)	40,841	(8,209)	3,059	(1)
Radiometric						
Gamma ray	15.1	(146,176)	41,841	(9,681)	2,771	(1)
Temperature gradient	.2*	(2,500)	1,000	(12,500)*	5,000*	(1)
Other	3.1	(7,250)	21,941	(2,339)	7,078	(3)
Other	1.0*	(1,200)	15,000	(1,200)*	15,000*	(13)
Oceanography						
Transition zone						
Seismic (*P*-wave)						
Electrical	1.2	[3]	43,580	[2]	35,431	[14,527]
Marine						
Seismic (*P*-wave)						
Dynamite	4.0	[1,000]	420,000	[250]	105,000	[420]
Compressed air	2.5	320	540,000	128	216,000	1,688
Compressed air	1.0	[3]	219,545	[3]	205,182	[73,182]
Electrical	27.6	27,942	3,221,900	1,012	116,736	115
Implosive	7.5	9,375	1,406,250	1,250	187,500	150
Seismic (refraction)						
Compressed air	1.5	1,121	345,655	733	225,918	308
3-D seismic[1]	4.7	19,955[1]	884,030	4,210[1]	186,504	44[1]
Airborne						
Gravity	4.0	[100,000]	1,600,000	[25,000]	400,000	[16]
Magnetic	1.1*	22,795	341,925	20,723*	310,841*	15
Drill hole						
Vertical seismic prof.	1.0	[1]	200,000	[1]	200,000	[200,000]
Research						
Land						
Seismic (*P*-wave)						
Dynamite	16.5	2,398	3,384,000	145	205,091	1,411
Weight drop	9.0	5	70,500	1	7,790	12,587
Vibratory	17.5	602	2,322,001	34	132,308	3,857
Seismic (*S*-wave)						
Vibratory	1.7	20	241,000	11	137,714	12,050
Seismic (refraction)						
Dynamite	7.7	1,682	540,000	217	69,677	321
Weight drop	.7*	1	5,000	1*	7,143*	5,000
Passive monitoring	5.0*	41	23,000	8*	4,600*	561
3-D seismic[2]	1.0	20[2]	20,000	20[2]	20,000	1,000[2]
Gravity	20.5	[8,897]	268,195	[434]	13,083	[30]
Gravity	7.4*	[1,855]	53,975	[250]*	7,274	[29]
Magnetic	14.3*	[19,115]	39,750	[1,337]*	2,780*	[2]
Resistivity	4.8*	[240]	45,200	[50]*	9,417*	[188]
Self-potential	.8	9	17,500	11	20,588	1,944
Sonic/velocity logging	1.0*	(500)	3,500	(500)*	3,500*	(7)
Electromagnetic						
Time domain	1.2	80	180,000	67	150,000	2,250
Time domain	.7	[70]	30,000	[93]	40,000	[429]
Frequency domain	7.5*	35	12,500	5*	1,667*	357

[1]These 3-D data are a mix of line-miles and square miles. See Table 3 or 5 for exact breakdown.
[2]All these 3-D data reported in square miles.

Table 17. Worldwide average unit costs by survey objective, type, and method (cont.).

Survey objective, type and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs – US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Research, Land, continued						
Combined EM/Mag.						
Frequency domain	.5	14	5,000	28	10,000	357
VLF	.5	2	1,000	4	2,000	500
Magnetotelluric						
Natural field	3.0	[81]	300,000	[27]	100,000	[3,704]
Controlled source	.5	[1]	10,000	[2]	20,000	[10,000]
Other	10.0	2,500	70,000	250	7,000	28
Transition zone						
Seismic (*S*-wave)						
Compressed air	1.0	200	240,000	200	240,000	1,200
Seismic (refraction)						
Passive monitoring	.1	[1]	2,870	[33]	95,667	[2,870]
Marine						
Seismic (*P*-wave)						
Compressed air	16.6	33,382	5,000,707	2,005	300,343	150
Electrical	3.0	1,500	250,000	500	83,333	167
Seismic (refraction)						
Dynamite	.2	20	62,500	80	250,000	3,125
Dynamite	5.3*	200	96,000	38*	18,113*	480
Compressed air	2.5	6,430	361,000	2,492	139,922	56
Solid chemical	.2	400	29,000	1,600	116,000	73
Passive monitoring	.1	[1]	1,140	[33]	38,000	[1,140]
Gravity	16.2	44,532	2,903,043	2,749	179,200	65
Magnetic	14.0	57,759	2,141,870	4,126	152,991	37
Other	6.7	30,300	5,100,000	4,489	755,556	168
Airborne						
Magnetic	17.5	175,085	1,554,571	10,005	88,833	9
Electromagnetic						
Frequency domain	6.0*	600	130,000	100*	21,667*	217
Combined EM/Mag.						
VLF	10.0	24,000	1,200,000	2,400	120,000	50
Remote sensing						
Multispectral scanning	.1	70	840	700	8,400	12
Multispectral scanning	1.5	[36]	12,600	[24]	8,400	[350]
Drill hole						
Magnetic	2.0*	(10,000)	155,000	(5,000)*	77,500*	(16)
Radiometric						
Gamma ray	2.1*	(32,377)	16,439	(15,418)*	7,828*	(1)
Vertical seismic prof.	1.5	[20]	300,000	[13]	200,000	[15,000]

individuals who were instrumental in preparing and submitting their activity questionnaires. The Committee welcomes comments and suggestions on ways to improve this report.

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